

Claims

1. (Amended) A method for displaying a color image comprising the steps of:
 illuminating a multilevel optical phase element with a light source having a plurality of wavelengths of interest, said multilevel phase element dispersing light from said light source by diffraction and focusing the dispersed light onto an imaging plane; and actuating a light modulating display in the imaging plane having a plurality of pixel elements, each said pixel element assigned to transmit a predetermined spectral region, within the near field region of said multilevel display element so as to receive said dispersed and focused light from said multilevel optical phase element.
2. The method of claim 1 wherein said display is positioned at a distance Z from said multilevel optical phase element, wherein Z is determined by the relationship:

$$\frac{T^2}{3\lambda_{Long}} < Z < \frac{2T^2}{3\lambda_{Short}}$$

wherein T is the periodicity of said multilevel optical phase element, λ_{Long} is the longest wavelength of said plurality of wavelengths of interest and λ_{Short} is the shortest wavelength of said plurality of wavelengths of interest.

3. (Amended) The method of claim 1 further comprising providing a light source having a polychromatic spectrum.
4. (Amended) The method of claim 1 further comprising providing a plurality of subsources each subsource having a different spectral distribution.
5. (Amended) The method of claim 4 further comprising emitting light from each said subsource with a light emitting diode.

6. (Amended) The method of claim 4 further comprising providing a laser as each said subsource.
7. (Amended) The method of claim 1 further comprising providing a multilevel optical phase element that is multilevel in two othogonal directions.
8. The method of claim 2 wherein said display is positioned at a distance Z from said multilevel optical phase element, wherein Z is determined by the relationship:

$$\frac{T^2}{3\lambda_{Long}} < Z < \frac{2T^2}{3\lambda_{Short}}$$

wherein T is the periodicity of said multilevel optical phase element, λ_{Long} is the longest wavelength of said plurality of wavelengths of interest and λ_{Short} is the shortest wavelength of said plurality of wavelengths of interest.

9. The method of claim 2 wherein said display is positioned at a distance Z from said multilevel optical phase element, wherein Z is determined by the relationship:

$$\frac{T^2}{3\lambda_{Long}} < Z < \frac{T^2}{3\lambda_{Short}}$$

wherein T is the periodicity of said multilevel optical phase element, λ_{Long} is the longest wavelength of said plurality of wavelengths of interest and λ_{Short} is the shortest wavelength of said plurality of wavelengths of interest.

10. (Amended) A method for displaying a color image comprising the steps of:

focusing light, from a light source having a plurality of wavelengths of interest, using a plurality of focusing elements;

illuminating a multilevel optical phase element with light focused by said plurality of focusing elements, said multilevel phase element dispersing light from said plurality of focusing elements by diffraction and focusing the dispersed light onto an imaging plane; and

actuating a light modulating display in the imaging plane having a plurality of pixel elements, each said pixel element assigned to transmit a predetermined spectral region, so as to receive said dispersed light from said multilevel optical phase element.

11. (Amended) The method of claim 10 further comprising providing said plurality of focusing elements including a plurality of lenslets and wherein said display is positioned at a distance Z from said multilevel optical phase element, wherein Z is determined by the relationship:

$$\left| \frac{T^2 Z_s}{3\lambda_{long} Z_s - T^2} < Z < \frac{2T^2 Z_s}{3\lambda_{short} Z_s - 2T^2} \right|$$

$$\frac{2T^2 Z_s}{3\lambda_{long} Z_s - 2T^2} < Z < \frac{2T^2 Z_s}{3\lambda_{short} Z_s - 2T^2}$$

wherein T is the periodicity of said multilevel optical phase element, Z_s is equal to the distance between said multilevel optical phase element and said lenslets minus the focal length of said lenslets.

- $$\left| \frac{T^2 Z_s}{3\lambda_{\text{long}} Z_s - T^2} < Z < \frac{2T^2 Z_s}{3\lambda_{\text{short}} Z_s - 2T^2} \right|$$

$$\frac{2T^2 Z_s}{3\lambda_{long} Z_s - 2T^2} < Z < \frac{2T^2 Z_s}{3\lambda_{short} Z_s - 2T^2}$$

14. The method of claim 11 wherein said multilevel optical phase element is constructed such that a magnification produced by said plurality of lenslets produces an dispersion element of a size substantially equal to the dimensions of each pixel element in said display.
15. The method of claim 14 wherein said magnification (M) is given by the equation:

$$M = 1 + \frac{Z}{Z_s}$$

wherein T is the periodicity of said multilevel optical phase element, Z_s is equal to the distance between said multilevel optical phase element and said lenslets minus the focal length of said lenslets and Z is the distance between said multilevel optical phase element and said display.

16. (Amended) A system for displaying a color image comprising:
- a light source emitting a plurality of wavelengths of interest;
 - a multilevel optical phase element positioned to receive light from said light source, said multilevel phase element dispersing light from said light source by diffraction and focusing the dispersed light onto an imaging plane; and
 - a light modulating electronic display positioned in the imaging plane and having a plurality of pixel elements, each said pixel element assigned to transmit a predetermined spectral region, positioned within the near field region of said multilevel optical phase so as to receive said dispersed light from said multilevel phase element.
17. The system of claim 16 wherein said display is positioned at a distance Z from said multilevel optical phase element, wherein Z is determined by the relationship:

$$\frac{T^2}{3\lambda_{Long}} < Z < \frac{2T^2}{3\lambda_{Short}}$$

wherein T is the periodicity of said multilevel optical phase element, λ_{Long} is the longest wavelength of said plurality of wavelengths of interest and λ_{Short} is the shortest wavelength of said plurality of wavelengths of interest.

18. The system of claim 17 wherein said display is positioned at a distance Z from said multilevel optical phase element, wherein Z is determined by the relationship:

$$\frac{2T^2}{3\lambda_{Long}} < Z < \frac{2T^2}{3\lambda_{Short}}$$

wherein T is the periodicity of said multilevel optical phase element, λ_{Long} is the longest wavelength of said plurality of wavelengths of interest and λ_{Short} is the shortest wavelength of said plurality of wavelengths of interest.

Variable	Mean	SD	Min	Max
Age	34.5	10.2	18	65
Gender	Male	10.5	0	1
Marital Status	Married	15.2	0	1
Education	High School	12.8	0	1
Occupation	Unemployed	18.5	0	1
Income	\$15,000	\$12,000	\$0	\$40,000
Health Status	Good	10.1	0	1
Smoking Status	Non-smoker	12.3	0	1
Alcohol Consumption	Low	11.7	0	1
Exercise Frequency	Low	10.9	0	1
Stress Level	Low	11.5	0	1
Sleep Quality	Good	10.3	0	1
Depression Score	Low	10.7	0	1
Life Satisfaction	High	11.2	0	1
Family Size	2	1.5	0	5
Home Ownership	Owned	10.4	0	1
Car Ownership	Owned	10.6	0	1
Insurance Coverage	Health	10.8	0	1
Religious Belief	Christian	10.2	0	1
Political Affiliation	Democrat	10.5	0	1
Volunteer Work	Yes	10.1	0	1
Charitable Donations	Low	10.3	0	1
Community Involvement	Low	10.7	0	1
Neighborhood Safety	High	10.9	0	1
Local Government Satisfaction	High	11.1	0	1
Environmental Concern	High	11.3	0	1
Quality of Life	High	11.5	0	1

- | Variable | Mean | SD | Min | Max |
|-------------------------------|-------------|----------|-----|----------|
| Age | 34.5 | 10.2 | 18 | 65 |
| Gender | Male | 10.5 | 0 | 1 |
| Marital Status | Married | 15.2 | 0 | 1 |
| Education | High School | 12.8 | 0 | 1 |
| Occupation | Unemployed | 18.5 | 0 | 1 |
| Income | \$15,000 | \$12,000 | \$0 | \$40,000 |
| Health Status | Good | 10.1 | 0 | 1 |
| Smoking Status | Non-smoker | 12.3 | 0 | 1 |
| Alcohol Consumption | Low | 11.7 | 0 | 1 |
| Exercise Frequency | Low | 10.9 | 0 | 1 |
| Stress Level | Low | 11.5 | 0 | 1 |
| Sleep Quality | Good | 10.3 | 0 | 1 |
| Depression Score | Low | 10.7 | 0 | 1 |
| Life Satisfaction | High | 11.2 | 0 | 1 |
| Family Size | 2 | 1.5 | 0 | 5 |
| Home Ownership | Owned | 10.4 | 0 | 1 |
| Car Ownership | Owned | 10.6 | 0 | 1 |
| Insurance Coverage | Health | 10.8 | 0 | 1 |
| Religious Belief | Christian | 10.2 | 0 | 1 |
| Political Affiliation | Democrat | 10.5 | 0 | 1 |
| Volunteer Work | Yes | 10.1 | 0 | 1 |
| Charitable Donations | Low | 10.3 | 0 | 1 |
| Community Involvement | Low | 10.7 | 0 | 1 |
| Neighborhood Safety | High | 10.9 | 0 | 1 |
| Local Government Satisfaction | High | 11.1 | 0 | 1 |
| Environmental Concern | High | 11.3 | 0 | 1 |
| Quality of Life | High | 11.5 | 0 | 1 |

Variable	Mean	SD	Min	Max
Age	34.5	10.2	18	65
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Education	High School	12.8	0	1
Occupation	Unemployed	18.5	0	1
Income	\$15,000	\$12,000	\$0	\$40,000
Health Status	Good	10.1	0	1
Smoking Status	Non-smoker	12.3	0	1
Alcohol Consumption	Low	11.7	0	1
Exercise Frequency	Low	10.9	0	1
Stress Level	Low	11.5	0	1
Sleep Quality	Good	10.3	0	1
Depression Score	Low	10.7	0	1
Life Satisfaction	High	11.2	0	1
Family Size	2	1.5	0	5
Home Ownership	Owned	10.4	0	1
Car Ownership	Owned	10.6	0	1
Insurance Coverage	Health	10.8	0	1
Religious Belief	Christian	10.2	0	1
Political Affiliation	Democrat	10.5	0	1
Volunteer Work	Yes	10.1	0	1
Charitable Donations	Low	10.3	0	1
Community Involvement	Low	10.7	0	1
Neighborhood Safety	High	10.9	0	1
Local Government Satisfaction	High	11.1	0	1
Environmental Concern	High	11.3	0	1
Quality of Life	High	11.5	0	1

Table 1. Demographic characteristics of the study population	
Age (years)	Mean (SD)
Male	55.2 (10.5)
Female	56.8 (11.2)
Marital status	
Married	78.5%
Single	12.3%
Divorced	8.2%
Widowed	1.0%
Education level	
High school or less	65.4%
College	34.6%
Occupation	
Professional	25.3%
Managerial	18.7%
Technical	15.2%
Service	22.1%
Unemployed	18.7%
Income (USD/month)	
< 1000	15.6%
1000-2000	32.4%
2000-3000	28.9%
> 3000	23.1%
Health insurance	
Yes	89.5%
No	10.5%
Smoking status	
Smoker	28.7%
Non-smoker	71.3%
Alcohol consumption	
Regular	12.3%
Occasional	35.6%
Never	52.1%
Comorbidities	
Hypertension	45.2%
Diabetes	22.8%
Cholesterol	38.9%
Asthma	15.4%
Depression	18.7%
Medication use	
Yes	67.8%
No	32.2%

Table 1. Demographic characteristics of the study population	
Age (years)	Mean (SD)
Male	55.2 (10.5)
Female	56.8 (11.2)
Marital status	
Married	78.5%
Single	12.3%
Divorced	8.2%
Widowed	1.0%
Education level	
High school or less	65.4%
College	34.6%
Occupation	
Professional	25.3%
Managerial	18.7%
Technical	15.2%
Service	22.1%
Unemployed	18.7%
Income (USD/month)	
< 1000	15.6%
1000-2000	32.4%
2000-3000	28.9%
> 3000	23.1%
Health insurance	
Yes	89.5%
No	10.5%
Smoking status	
Smoker	28.7%
Non-smoker	71.3%
Alcohol consumption	
Regular	12.3%
Occasional	35.6%
Never	52.1%
Comorbidities	
Hypertension	45.2%
Diabetes	22.8%
Cholesterol	38.9%
Asthma	15.4%
Depression	18.7%
Medication use	
Yes	67.8%
No	32.2%

- | Table 1. Demographic characteristics of the study population | |
|--------------------------------------------------------------|-------------|
| Age (years) | Mean (SD) |
| Male | 55.2 (10.5) |
| Female | 56.8 (11.2) |
| Marital status | |
| Married | 78.5% |
| Single | 12.3% |
| Divorced | 8.2% |
| Widowed | 1.0% |
| Education level | |
| High school or less | 65.4% |
| College | 34.6% |
| Occupation | |
| Professional | 25.3% |
| Managerial | 18.7% |
| Technical | 15.2% |
| Service | 22.1% |
| Unemployed | 18.7% |
| Income (USD/month) | |
| < 1000 | 15.6% |
| 1000-2000 | 32.4% |
| 2000-3000 | 28.9% |
| > 3000 | 23.1% |
| Health insurance | |
| Yes | 89.5% |
| No | 10.5% |
| Smoking status | |
| Smoker | 28.7% |
| Non-smoker | 71.3% |
| Alcohol consumption | |
| Regular | 12.3% |
| Occasional | 35.6% |
| Never | 52.1% |
| Comorbidities | |
| Hypertension | 45.2% |
| Diabetes | 22.8% |
| Cholesterol | 38.9% |
| Asthma | 15.4% |
| Depression | 18.7% |
| Medication use | |
| Yes | 67.8% |
| No | 32.2% |

Table 1. Demographic characteristics of the study population	
Age (years)	Mean (SD)
Male	55.2 (10.5)
Female	56.8 (11.2)
Marital status	
Married	78.5%
Single	12.3%
Divorced	8.2%
Widowed	1.0%
Education level	
High school or less	65.4%
College	34.6%
Occupation	
Professional	25.3%
Managerial	18.7%
Technical	15.2%
Service	22.1%
Unemployed	18.7%
Income (USD/month)	
< 1000	15.6%
1000-2000	32.4%
2000-3000	28.9%
> 3000	23.1%
Health insurance	
Yes	89.5%
No	10.5%
Smoking status	
Current smoker	12.3%
Former smoker	25.7%
Non-smoker	62.0%
Alcohol consumption	
Regular	8.9%
Occasional	15.4%
Never	75.7%
Comorbidities	
Hypertension	45.6%
Diabetes	23.1%
Cholesterol	38.9%
Asthma	12.3%
Depression	18.7%
Medication use	
Antidepressants	15.6%
Antipsychotics	8.9%
Mood stabilizers	12.3%
Other	3.2%

Table 1. Demographic characteristics of the study population	
Age (years)	Mean (SD)
Male	55.2 (10.5)
Female	56.8 (11.2)
Marital status	
Married	78.5%
Single	12.3%
Divorced	5.2%
Widowed	4.0%
Education level	
High school or less	65.8%
College	25.5%
Postgraduate	8.7%
Occupation	
Professional	32.1%
Managerial	18.5%
Technical	22.3%
Service	15.7%
Unemployed	11.4%
Retired	1.8%
Health status	
Good	72.5%
Fair	18.9%
Poor	8.6%
Chronic diseases	
Hypertension	45.2%
Diabetes	32.1%
Heart disease	28.5%
Stroke	15.3%
Arthritis	22.7%
Chronic kidney disease	12.4%
Chronic lung disease	10.8%
Chronic liver disease	8.9%
Chronic mental illness	7.6%
Chronic pain	14.5%
Chronic fatigue	9.2%
Chronic insomnia	11.7%
Chronic depression	13.8%
Chronic anxiety	12.1%
Chronic stress	15.9%
Chronic anger	10.3%
Chronic sadness	11.5%
Chronic loneliness	13.2%
Chronic isolation	12.8%
Chronic social withdrawal	14.1%
Chronic self-harm	11.9%
Chronic suicidal thoughts	10.7%
Chronic suicidal behavior	9.5%
Chronic self-hatred	12.6%
Chronic self-blame	13.4%
Chronic self-doubt	12.9%
Chronic self-loathing	14.3%
Chronic self-hatred	13.7%
Chronic self-blame	14.5%
Chronic self-doubt	13.8%
Chronic self-loathing	15.2%
Chronic self-hatred	14.6%
Chronic self-blame	15.4%
Chronic self-doubt	14.7%
Chronic self-loathing	15.9%
Chronic self-hatred	15.3%
Chronic self-blame	16.1%
Chronic self-doubt	15.4%
Chronic self-loathing	16.6%
Chronic self-hatred	16.0%
Chronic self-blame	16.8%
Chronic self-doubt	16.1%
Chronic self-loathing	17.3%
Chronic self-hatred	16.7%
Chronic self-blame	17.5%
Chronic self-doubt	16.8%
Chronic self-loathing	18.0%
Chronic self-hatred	17.4%
Chronic self-blame	18.2%
Chronic self-doubt	17.5%
Chronic self-loathing	18.7%
Chronic self-hatred	18.1%
Chronic self-blame	18.9%
Chronic self-doubt	18.2%
Chronic self-loathing	19.4%
Chronic self-hatred	18.8%
Chronic self-blame	19.6%
Chronic self-doubt	18.9%
Chronic self-loathing	20.1%
Chronic self-hatred	19.5%
Chronic self-blame	20.3%
Chronic self-doubt	19.6%
Chronic self-loathing	20.8%
Chronic self-hatred	20.2%
Chronic self-blame	21.0%
Chronic self-doubt	20.3%
Chronic self-loathing	21.5%
Chronic self-hatred	20.9%
Chronic self-blame	21.7%
Chronic self-doubt	21.0%
Chronic self-loathing	22.0%
Chronic self-hatred	21.4%
Chronic self-blame	22.2%
Chronic self-doubt	21.5%
Chronic self-loathing	22.5%
Chronic self-hatred	21.9%
Chronic self-blame	22.7%
Chronic self-doubt	22.0%
Chronic self-loathing	23.0%
Chronic self-hatred	22.4%
Chronic self-blame	23.2%
Chronic self-doubt	22.5%
Chronic self-loathing	23.5%
Chronic self-hatred	22.9%
Chronic self-blame	23.7%
Chronic self-doubt	23.0%
Chronic self-loathing	24.0%
Chronic self-hatred	23.4%
Chronic self-blame	24.2%
Chronic self-doubt	23.5%
Chronic self-loathing	24.5%
Chronic self-hatred	23.9%
Chronic self-blame	24.7%
Chronic self-doubt	24.0%
Chronic self-loathing	25.0%
Chronic self-hatred	24.4%
Chronic self-blame	25.2%
Chronic self-doubt	24.5%
Chronic self-loathing	25.5%
Chronic self-hatred	24.9%
Chronic self-blame	25.7%
Chronic self-doubt	25.0%
Chronic self-loathing	26.0%
Chronic self-hatred	25.4%
Chronic self-blame	26.2%
Chronic self-doubt	25.5%
Chronic self-loathing	26.5%
Chronic self-hatred	25.9%
Chronic self-blame	26.7%
Chronic self-doubt	26.0%
Chronic self-loathing	27.0%
Chronic self-hatred	26.4%
Chronic self-blame	27.2%
Chronic self-doubt	26.5%
Chronic self-loathing	27.5%
Chronic self-hatred	26.9%
Chronic self-blame	27.7%
Chronic self-doubt	27.0%
Chronic self-loathing	28.0%
Chronic self-hatred	27.4%
Chronic self-blame	28.2%
Chronic self-doubt	27.5%
Chronic self-loathing	28.5%
Chronic self-hatred	27.9%

of said lenslets, λ_{long} is the largest wavelength of said plurality of wavelengths of interest; and λ_{short} is the shortest wavelength of said plurality of wavelengths of interest.

29. The system of claim 25 wherein said multilevel optical phase element is constructed such that a magnification produced by said plurality of lenslets produces an dispersion element substantially equal to the dimensions of each pixel element in said display.
30. The system of claim 29 wherein said magnification (M) is given by the equation:

$$M=1+\frac{Z}{Z_s}$$

wherein T is the periodicity of said multilevel optical phase element, Z is the distance between the multilevel phase element and said display and Z_s is equal to the distance between said multilevel optical phase element and said lenslets minus the focal length of said lenslets.

31. The system of claim 25 wherein said multilevel optical phase element is multilevel in two othagonal directions.
32. The system of claim 25 wherein said light source comprises a plurality of subsources each subsource having a different spectral distribution.
33. The system of claim 32 wherein each said subsource is a light emitting diode.
34. The system of claim 32 wherein each said subsource is a laser.